

WHAT IS CLAIMED IS:

1 1. A method of managing a generational memory, the method comprising:
2 sampling, at run-time of an execution sequence, lifetimes of a representative
3 subset of memory objects in the generational memory; and
4 pretenuring, based on the sampled lifetimes, at least some of the memory
5 objects allocated from the generational memory during the execution
6 sequence.

1 2. The method of claim 1,
2 wherein the pretenuring is performed for those of the memory objects for
3 which corresponding sampled lifetimes exceed a first metric.

1 3. The method of claim 2,
2 wherein the pretenuring is reversed, if corresponding sampled lifetimes fall
3 below a second metric.

1 4. The method of claim 1,
2 wherein the pretenuring is performed while corresponding sampled lifetimes
3 exceed a metric.

1 5. The method of claim 1,
2 wherein the sampling includes sampling of representative subsets for plural
3 categories of the memory objects; and
4 further comprising:
5 allocating the memory objects using category-specific allocation
6 functionality; and
7 selectively modifying the category-specific allocation functionality to
8 pretenure, on subsequent allocations, memory objects
9 corresponding to those of the categories for which the sampled
10 lifetimes exceed a metric.

1 6. The method of claim 5,

2 wherein the selective modification of the category-specific allocation
3 functionality includes instantiating category-specific allocation
4 methods that allocate new objects of a corresponding category directly
5 into a tenured generation of the generational memory.

1 7. The method of claim 1,
2 wherein the sampled lifetimes are characterized as per-category, mean
3 lifetimes.

1 8. The method of claim 1,
2 wherein the sampled lifetimes are characterized as per-category, distributions
3 of lifetimes.

1 9. The method of claim 5,
2 wherein the categories are object class-specific.

1 10. The method of claim 5,
2 wherein the categories are call-site specific.

1 11. The method of claim 5,
2 wherein the categories correspond to activation record stack profiles.

1 12. The method of claim 5,
2 wherein the categories correspond to both type of memory object and call-site
3 for allocation thereof; and
4 wherein the selective modification of the category-specific allocation
5 functionality includes in-lining instructions at the corresponding call-
6 site, the in-lined instructions allocating new memory objects of the
7 corresponding type directly into a tenured generation of the
8 generational memory.

1 13. The method of claim 1,
2 wherein the sampling includes sampling of representative subsets of the
3 memory objects for plural categories thereof; and

4 wherein the pretenuring is performed on a category-specific basis.

1 14. The method of claim 1, further comprising:
2 establishing weak references to respective of the sampled memory objects and
3 associating allocation-time information therewith; and
4 identifying those of the sampled memory objects that become unreachable
5 using the weak references.

1 15. The method of claim 14, wherein the weak references include one of:
2 phantom references;
3 references of strength less than any other reference by which an unreachable
4 one of the sampled objects may become reachable; and
5 references of strength less than any other reference employed in the
6 computational system.

1 16. The method of claim 1, further comprising:
2 selecting the representative subset based on allocation buffer overflow.

1 17. The method of claim 1, further comprising:
2 selecting the representative subset using per class allocator functionality.

1 18. The method of claim 1, further comprising:
2 selecting the representative subset based on identity of an allocating thread.

1 19. The method of claim 1, further comprising:
2 coincident with allocation of memory objects of the representative subset,
3 establishing weak references thereto and associating therewith
4 information indicative of at least allocation time and call site.

1 20. A method of operating an automatically reclaimed storage environment in
2 accordance with object lifetime statistics, the method comprising:
3 selecting representative subsets of memory objects for each of plural
4 categories thereof;

5 sampling, during a program execution, lifetimes of memory objects from the
6 representative subsets; and
7 tailoring, during the program execution, a storage management action based
8 on the sampled lifetimes for a corresponding one of the categories.

1 21. The method of claim 20,
2 wherein the storage management action includes pretenuring subsequently
3 allocated memory objects of the corresponding category.

1 22. The method of claim 20,
2 wherein the storage management action includes promoting memory objects
3 of the corresponding category to a particular generation.

1 23. The method of claim 20,
2 wherein the storage management action includes steering, on promotion,
3 memory objects of the corresponding category to a particular store.

1 24. The method of claim 20,
2 wherein the storage management action includes allocating subsequently
3 allocated memory objects of the corresponding category from a
4 particular store.

1 25. The method of claim 24,
2 wherein the particular store is selected from the set of thread-local storage and
3 global storage, based on the sampled lifetimes.

1 26. The method of claim 20,
2 wherein the storage management action includes modifying a category-
3 specific allocator in accordance with a storage management policy
4 adapted to the sampled lifetimes; and
5 instantiating the modified, category-specific allocator.

1 27. The method of claim 20,

2 wherein the automatically reclaimed storage environment includes a
 3 generational garbage collector; and
 4 wherein the storage management action includes generation selection for
 5 unsampled instances of the memory objects.

1 28. A storage management facility for a computational system, the storage
 2 management facility comprising:
 3 an object sampler operable to sample lifetimes of at least a subset of objects
 4 instantiated in the computational system during execution of a
 5 program; and
 6 a storage allocation facility operable during the execution of the program to
 7 allocate new objects corresponding to respective of the sampled
 8 objects based at least in part on the sampled object lifetimes.

1 29. The storage management facility of claim 28,
 2 wherein the object sampler samples lifetimes on a per object category basis;
 3 and
 4 wherein operation of the storage allocation facility is particular to each object
 5 category and based at least in part on the lifetimes of the sampled
 6 objects corresponding thereto.

1 30. The storage management facility of claim 28,
 2 wherein the storage allocation facility includes category-specific allocators;
 3 and
 4 wherein, in response to respective of the sampled object lifetimes exceeding a
 5 metric, the category-specific allocators are modified at run-time to
 6 pretenure objects allocated thereby.

1 31. The storage management facility of claim 28, wherein the categories
 2 correspond to one or more of:
 3 object type;
 4 allocation call site;
 5 activation record stack state;

6 thread id; and
7 receiver object.

1 32. The storage management facility of claim 28,
2 wherein the object sampler is responsive to transition of at least one of the
3 sampled objects from a reachable state to an unreachable state.

1 33. The storage management facility of claim 28,
2 wherein the object sampler employs a weak reference construct of the
3 computational system to identify those of the sampled objects that have
4 become unreachable.

1 34. The storage management facility of claim 33,
2 wherein the weak reference construct includes a phantom reference.

1 35. The storage management facility of claim 33,
2 wherein the weak reference construct includes a virtual-machine-level weak
3 reference of strength less than any other weak reference by which an
4 unreachable instance of the sampled objects may become reachable.

1 36. The storage management facility of claim 33,
2 wherein the weak reference construct includes a virtual-machine-level weak
3 reference of strength less than any other weak reference employed in
4 the computational system.

1 37. The storage management facility of claim 28, further comprising:
2 a garbage collector,
3 wherein the object sampler is responsive to a storage management event of the
4 garbage collector affecting one or more of the sampled objects.

1 38. The storage management facility of claim 37,
2 wherein the storage management event includes collection of one or more of
3 the sampled objects.

1 39. The storage management facility of claim 37,
2 wherein the storage management event includes promotion of one or more of
3 the sampled objects from a younger generation to an older generation.

1 40. The storage management facility of claim 37, embodied as a computer
2 program product.

1 ; 41. A computer program product encoded in at least one computer readable
2 medium, the computer program product comprising:
3 at least one functional sequence for maintaining per-category object lifetime
4 statistics based on a sampled subset of objects using weak references
5 and associated allocation time information; and
6 at least one functional sequence for tenuring objects in accordance with those
7 of the object lifetime statistics corresponding thereto.

1 42. A computer program product as recited in 41,
2 wherein the tenuring sequence is instantiated for a particular category when
3 corresponding object lifetime statistics exceed a metric.

1 43. A computer program product as recited in 42,
2 wherein the tenuring sequence replaces a category-specific allocator.

1 44. A computer program product as recited in 42,
2 wherein the tenuring sequence is replaced by a non-tenuring, category-specific
3 allocator when corresponding object lifetime statistics fall below a
4 second metric.

1 45. A computer program product as recited in 41,
2 wherein the at least one computer readable medium is selected from the set of
3 a disk, tape or other magnetic, optical, or electronic storage medium
4 and a network, wireline, wireless or other communications medium.

1 ; 46. An apparatus comprising:

2 means for sampling instances of software objects to maintain lifetime
3 predictions for categories thereof; and
4 means for altering object category-specific storage management policies at
5 run-time in response to the lifetime predictions.

1 47. The apparatus of claim 46, further comprising:
2 means for reversing the object category-specific storage management policies
3 at run-time in response to the lifetime predictions.